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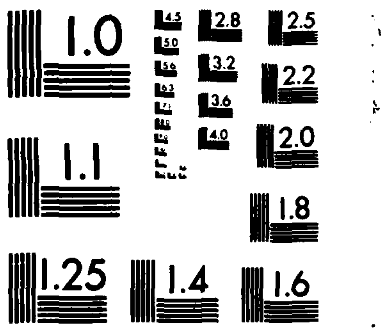

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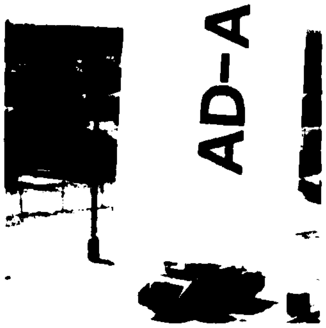

MISCELLANEOUS PAPER GL-85-2

REVIEW OF RIGID PAVEMENT DESIGN FOR VEHICULAR PARKING AREAS

by

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This paper documents proposed changes to TM 5-822-6, "Rigid Pavements for Roads, Streets, Walks, and Open Storage Areas." Changes are recommended in the areas of impact effects, the coverage versus thickness relationship, and effects of high-strength subgrades. Additionally, the criteria for design thickness of vehicular parking areas should be changed to account for a different slab loading condition, including load transfer at joints. These changes establish a rational and consistent basis for CE design of rigid airfield and nonairfield pavements.

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PREFACE

This review was conducted by the Geotechnical Laboratory (GL), US Army Engineer Waterways Experiment Station (WES), during the period February to September 1984. It was sponsored by the Office, Chief of Engineers, US Army, under the work effort "Review of Rigid Pavement Design of Vehicular Parking Areas" of the Facilities Investigation and Studies (FIS) Program.

The review was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, GL; Dr. T. D. White, Chief, Pavement Systems Division (PSD); Mr. Hugh L. Green, Chief, Engineering Analysis Group; and Mr. D. M. Ladd, Chief, Criteria Development Unit. The review was conducted by Dr. John C. Potter, PSD, who is the author of this paper.

The Commanders and Directors of WES during this review were COL Tilford C. Creel, CE, and COL Robert C. Lee, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, US CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

US customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimetres
miles (international) per hour	1.609344	kilometres per hour
pounds (force) per cubic inch	0.271477	newtons per cubic metre
pounds (force) per square inch	6.894757	kilopascals

REVIEW OF RIGID PAVEMENT DESIGN FOR VEHICULAR PARKING AREAS

PART I: INTRODUCTION

1. This paper describes the proposed changes to the design criteria used in TM 5-822-6, "Rigid Pavements for Roads, Streets, Walks, and Open Storage Areas" (Office, Chief of Engineers, Department of the Army 1984). The March 1984 edition of the TM recommends that rigid pavements for roads, streets, and vehicular parking areas be designed using criteria developed for roadways in 1961 (US Army Engineer Division, Ohio River, 1961). Since then, experience with test sections and in-service pavements has added to knowledge of pavement mechanics. The old criteria appear conservative, especially for vehicular parking areas, which are loaded differently from roadways.

2. The purpose of this review was to investigate the potential for reducing pavement design thicknesses, particularly for vehicular parking areas based on information developed since 1961. Topics given particular attention were (a) impact, (b) coverage versus thickness relationship, (c) effects of high-strength subgrades, (d) slab loading conditions, and (e) traffic channelization. The first three of these topics apply to roads and streets as well as vehicular parking areas. The latter two topics apply only to design of vehicular parking areas.

3. These changes will reflect current trends being pursued in rigid pavement design and will make the US Army Corps of Engineers (USACE) design philosophy for rigid airfield and nonairfield pavements consistent.

PART II: RECOMMENDED CHANGES

Roads, Streets, and Vehicular Parking Areas

4. The design criteria for roads, streets, and vehicular parking areas should be modified in the areas of impact, coverage versus thickness relationship, and effects of high-strength subgrades.

5. Tests have shown that test vehicles on pavements experience impact effects. However, the pavements themselves do not. The axle loads of a moving truck cause smaller stresses than those of a stopped truck. In the Maryland Road Test (Highway Research Board 1952), stresses were measured at pavement edges and tranverse joints for speeds up to 40 mph.* Stresses at outside edges decreased 30 percent when truck speeds were raised from creep to 40 mph. Stresses at transverse joint edges decreased 15 percent at 40 mph. Stresses were decreased still more when 3/4-in. boards were placed on the pavement to simulate joint faulting. Similar results were reported from the American Association of State Highway Officials (AASHO) Road Test (Highway Research Board 1962). This agrees with USACE experience and with the current philosophy for design of airfield pavements. Therefore, use of an impact factor is not justified.

6. Previously, the standard thickness (for 5,000 coverages) was calculated using a combined design factor of 1.55. This included a 25 percent increase in the static load for impact and a 30 percent increase for load repetition. Eliminating the impact factor reduces the combined design factor to 1.3, for a thickness reduction of about 11 percent.

7. The percent standard thickness versus coverage relationship should be eliminated and a design factor versus coverages relationship established. This will allow the actual, rather than standard, design thickness to be calculated from the thickness equation, by replacing the old standard thickness design factor of 1.3 with the design factor determined from the new design factor versus coverage relationship. Using the new design factor versus coverages relationship for airfield pavements (revised under the USACE Facilities Investigation and Studies Program work effort "Review of Rigid Pavement Design Criteria") will incorporate data not included in development of the

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* A table of factors for converting US customary units of measurement to metric (SI) units is presented on page 3.

percent thickness versus coverages relationship, and will preserve the consistency between the airfield and nonairfield rigid pavement design criteria.

8. The change in thickness of roads, streets, and vehicular parking areas resulting from this modification depends upon the design traffic coverage level. For low coverage levels, the design thickness is reduced as much as 4 percent. For high coverage levels, the thickness is increased as much as 19 percent.

9. Current airfield pavement design includes a thickness reduction for high-strength subgrades. This reduction is based on USACE experience, and its validity is illustrated by the performance of concrete block pavements on high-strength subgrades. This same reduction (Hutchinson 1966) has been applied for roads, streets, and vehicular parking areas. The amount of thickness reduction depends upon the value of the modulus of soil reaction, k . For k values above 100 pci, the reduction in design thickness varies from zero (at $k = 200$ pci) to a maximum of 19.1 percent (at $k = 500$ pci).

10. The cumulative change in design thicknesses of roads and streets depends upon the coverage level (design index) and subgrade strength. It varies from an increase of 9 percent to a decrease of 19 percent for typical values of design parameters. The new rigid pavement design curves for roads and streets are shown in Figure 1.

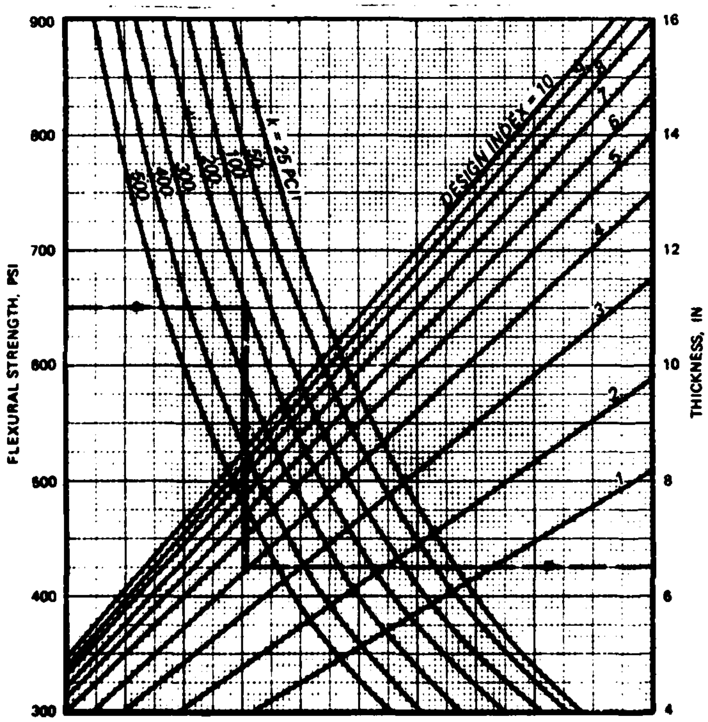

Figure 1. Rigid pavement design curves for roads and streets

Vehicular Parking Areas Only

11. A survey of parking areas and traffic patterns on various military installations was conducted by the project engineer. One observation from this survey is that traffic avoids the free edges of parking lot pavements. This phenomenon is caused by curbs, fences, buildings, soft ground, etc., common along the edges of parking areas. Since the free edges are not heavily trafficked, the maximum damage to parking lot pavements results from stresses caused by traffic loads along interior joints rather than along free edges. These interior joints are load transfer joints. A 25 percent load transfer is used for interior joints of airfield pavements (Parker et al. 1979). Therefore, the maximum design stresses in parking lot pavements can be estimated at 75 percent of the free edge stresses. Using these reduced stresses allows a design thickness reduction of about 17 percent.

12. No changes have been made in the traffic distribution assumptions used for the design of roads and streets. Several observations from the parking lot survey support this decision. First, parking lot stall and aisle widths are similar to traffic lane widths on roads and streets. Second, traffic flow in parking areas is restricted to road and street dimensions at entrances and exits. Thus, parking lot traffic distributions are similar to those of roadways in the highly trafficked areas. Finally, parking area flow patterns are subject to change over the life of the facility. Hence, distribution assumptions dependent upon permanent traffic flow patterns would be inappropriate.

13. The cumulative decrease in parking area design thickness, depending upon coverage level and subgrade strength, is 12 to 27 percent for typical values of design parameters. The new rigid pavement design curves for vehicular parking areas are shown in Figure 2.

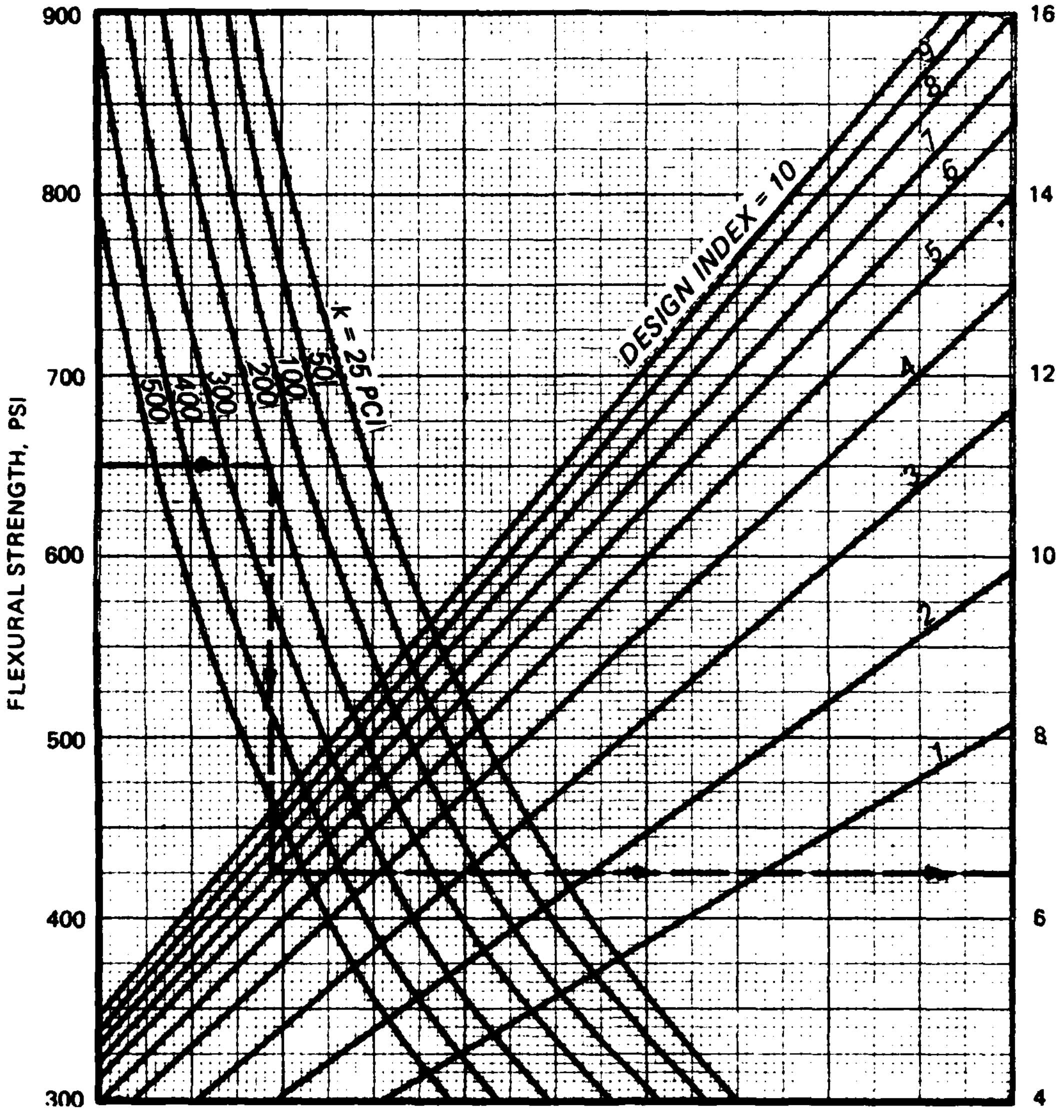

Figure 2. Rigid pavement design curves for parking areas

PART III: SUMMARY

14. The proposed design criteria for roads, streets, and vehicular parking areas include modifications to eliminate the impact factor, use a design factor based on new and reevaluated test section data, and provide for thickness reductions for high-strength subgrades. In addition, vehicular parking areas are designed using the stresses computed for interior, load-transfer joints, rather than for free edges.

15. The thickness changes produced by these modifications are shown in Table 1. Note that the actual, cumulative changes are limited by the minimum allowable thickness for plain concrete pavement of 6 in., specified by TM 5-822-6 (Office, Chief of Engineers, Department of the Army 1984).

Table 1

Percent Change in Thickness

Source	Roads and Streets	Vehicular Parking Areas	Remarks
Impact factor	-11	-11	
Percent standard thickness versus coverages	-4 to +19	-4 to +19	Depends upon coverage level
High-strength subgrade	-19.2 to 0	-19.2 to 0	Depends upon subgrade strength
Load transfer	0	-17	
Theoretical total	-31 to +6	-43 to -12	
Actual total	-19 to +9	-27 to -12	For resonable values of material properties

16. These changes establish a consistent basis for USACE design of all rigid pavements and reflect the current doctrine and state of the art.

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